Preliminary results on the biogeochemistry in the Mekong estuary and delta (Vietnam)

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✓Introduction

Estuaries play a significant role in the global CO_2 cycle, as they could emit about 0.43 Pg C yr^{-1} roughly balancing the absorption of CO_2 by the ensemble of other coastal ecosystems of -0.32 Pg C yr^{-1} (Borges 2005). However, these computations are based on a very limited number of air-water CO_2 flux estimates, in particular at tropical and subtropical latitudes (only 3 estuaries). Nevertheless, tropical regions receive about 60% of the global freshwater and organic carbon river inputs, thus, estuaries at these latitudes are expected to have a major role in the overall budget of CO_2 in the coastal and global oceans. Here, we report preliminary results from a biogeochemical study centered on CO_2 dynamics in the Mekong delta (Vietnam) that is the 10th largest river system in the world in terms of freshwater discharge.

✓Results & discussion

Three surveys were carried out in April 2004, October 2004 and December 2003 corresponding, respectively, to the middle of the dry season, middle of the wet season and end of the wet season (Plot 1) in the three main branches of the Mekong delta (Tien, Ham Luong and Co Chien, Plot 2). In October, freshwater was present down the mouth of the 3 main branches of the delta and in April brackish waters were observed within the 3 main branches of the delta (Plot 2).

The distinct increase of TA in April compared to the other 2 surveys (Plot 3) is related to enhanced weathering of carbonate rocks (increases of Ca^{2+} and Mg^{2+}, Tables 1 & 2) and silicate rocks (increases of Na^+ and K^+, Tables 1 & 2).

Table 1. Average concentrations at zero salinity (mmol kg^{-1})

	TA	Ca^{2+}	Mg^{2+}	Na^+	K^+
April	1.45	0.57	0.33	1.15	0.07
Oct	0.95	0.36	0.13	0.28	0.05
Dec	1.02	0.39	0.17	0.35	0.04

Table 2. Main magnesian carbonate and silicate weathering reactions and TA definition

Feldspar:	$2NaAlSi_3O_8 + 3H_2O + 2CO_2 \rightarrow 2Na^+ + 2HCO_3^- + Al_2Si_2O_5(OH)_4 + 4SiO_2$
K-Feldspar:	$2KAlSi_3O_8 + 3H_2O + 2CO_2 \rightarrow 2K^+ + 2HCO_3^- + Al_2Si_2O_5(OH)_4 + 4SiO_2$
$(Ca_n,Mg_m)CO_3$:	$(Ca_n,Mg_m)CO_3 + H_2O + CO_2 \rightarrow nCa^{2+} + mMg^{2+} + 2HCO_3^-$
	$TA = [HCO_3^-] + 2[CO_3^{2-}] + [minor\ species]$

Data in Table 1 also suggest slightly higher weathering of carbonate and silicate rocks in December than in October. For the 3 surveys, chemical weathering signals are inversely related to freshwater discharge, probably due to a more rapid flushing of water from soils during peak flow events.

The higher freshwater DIC values in April compared to the other 2 surveys (Plot 4) were related to higher carbonate alkalinity since freshwater pCO_2 values were actually lower in April compared to the other 2 surveys (Plot 5). This was related to a phytoplankton bloom in freshwaters consistent with higher $\delta^{13}C$ DIC (Plot 6) and $\%O_2$ (Plot 7) values and lower Si concentrations (Plot 8). As phytoplankton entered the estuary it was degraded in the region of salinities < 5 (due to haline stress on the freshwater phytoplankton communities) as shown by the increases of pCO_2 and Si (Plots 5 and 8) and decrease of $\%O_2$ (Plot 7).

In April and December, most parameters followed dilution lines in the salinity mixing zone and the apparent scatter in trends of variables as a function of salinity was related to differences between the 3 main branches of the delta. In October, in the region of salinities > 7, a phytoplankton bloom controlled most variables as indicated by pCO_2 values close to or below atmospheric equilibrium (dotted line in plot 5) and higher $\delta^{13}C$ DIC (Plot 6) and $\%O_2$ (Plot 7) values. This was probably related to a decrease of light limitation as indicated by the much lower suspended particulate matter (SPM) values in October (average of 9.5 mg L^{-1} for salinities > 7) than in April (average of 54.8 mg L^{-1} for salinities > 7) and December (average of 20.2 mg L^{-1} for salinities > 7). The extension of the salinity mixing region over the continental shelf in October (Plot 2) allowed a higher sedimentation of SPM from the surface to bottom of the water column compared to the other 2 surveys.

Values of pCO_2 in the Mekong delta (280-4110 ppm, 10°N) are close to those reported in the Mandovi-Zuari estuary (500-3500 ppm, 15°N, Sarma et al. 2001) and the Pearl River estuary (370-4800ppm, 23°N, Zhai et al. 2005) but well above those reported in Hooghly estuary (80-1520 ppm, 22°N, Mukhopadhyay et al. 2002) and the Godavari estuary (220-500 ppm, 17°N, Bouillon et al. 2003) and well below those reported in the Tana estuary (140-10,040 ppm, 8°N, Bouillon et al. 2005) and the Kidogoweni estuary (500-6500 ppm, 4°S, Borges et al. 2004). Understanding the causes of such large variability of pCO_2 in tropical and subtropical estuaries is critical for reliable global estimates of sinks and sources of CO_2 in coastal ecosystems.

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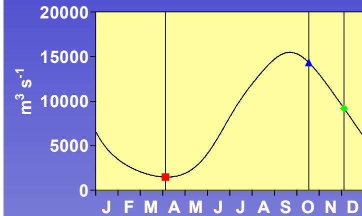
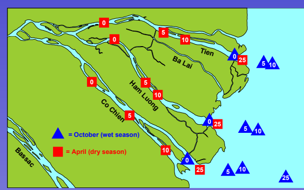
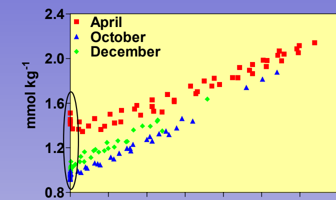
1. Climatological Freshwater discharge at My Thuan



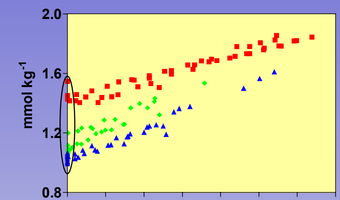
2. Salinity variations in the Mekong delta



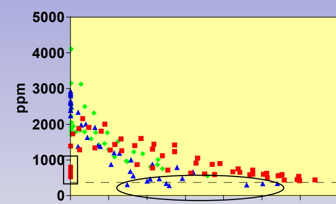
3. Total alkalinity (TA)



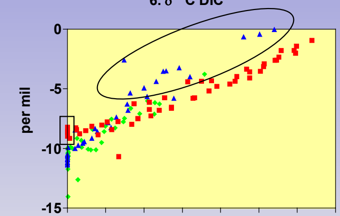
4. Dissolved inorganic carbon (DIC)



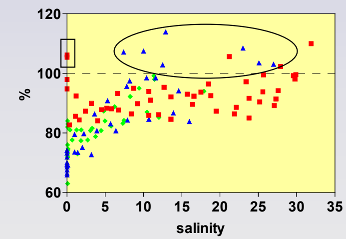
5. Partial pressure of CO_2 (pCO_2)



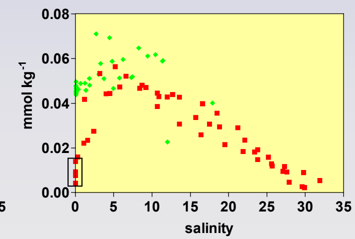
6. $\delta^{13}C$ DIC



7. Oxygen saturation level ($\%O_2$)



8. Silicate (Si)



www.ulg.ac.be/oceanbio/co2/
www.vub.ac.be/mangrove/

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